

APPENDIX MIDEX 6
Explorer Program Plan
**Program Level Requirements
for the
Wide – field Infrared Survey Explorer (WISE) Project**

1. SCOPE

This appendix to the Explorer Program Plan identifies the mission, science and programmatic (funding and schedule) requirements imposed on the University of California at Los Angeles (UCLA) and the Goddard Space Flight Center (GSFC) for the development and operation of the Wide-field Infrared Survey Explorer (WISE) Project of the Explorer Program. Requirements begin in Section 4. Sections 1, 2, and 3 are intended to set the context for the requirements that follow.

This document serves as the basis for mission assessments conducted by NASA Headquarters during the development period and provides the baseline for the determination of the science mission success following the completion of the operational phase.

Program authority is delegated from Associate Administrator of the Science Mission Directorate (AA/SMD) through the Explorer Program Manager within the Flight Projects Directorate at GSFC to the WISE Project Manager at JPL. Both Center Directors are expected to certify for their centers the readiness of the project to proceed at phase transitions and for launch, prior to a decision by NASA Headquarters.

The Principal Investigator (PI) is responsible for the scientific success of the WISE Project. He will be assisted by the set of approved co-investigators reflected in the proposal including any approved changes prior to the release of this appendix. The PI will be funded through a contract between GSFC and UCLA.

The PI is responsible for design, development, test, mission operations, and data verification tasks and shall coordinate the work of all contractors and co-investigators.

Changes to information and requirements contained in this document require approval by the AA/SMD, NASA Headquarters.

2. SCIENCE DEFINITION

2.1 Baseline Scientific Objectives

The Wide-field Infrared Survey Explorer is designed to complete the reconnaissance of the infrared sky and thus increase the utility of future observatory class infrared telescopes such as the James Webb Space Telescope. The overriding scientific goal is to perform a mid-infrared survey with sensitivity comparable to the bracketing surveys, which are the 2 Micron All-Sky Survey (2MASS) in the near infrared, and the Infrared Imaging Surveyor (IRIS) far-infrared survey (the Japanese Astro-F mission).

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The next tier of WISE science goals involves superlative and/or unique objects. These goals cannot be achieved by deep, pencil beam surveys which could be performed using observatories like the Spitzer Space telescope. The two primary goals identified by the WISE proposal are finding the closest brown dwarf stars to the Sun and finding the most luminous galaxies in the Universe. The WISE mission sensitivity and filter set are designed to easily identify these extreme objects in the universe.

Other scientific objectives are achieved through the very nature of the WISE mission, a sensitive all-sky survey. The legacy of all-sky surveys endures for decades, and the data will be applicable to a wide variety of astrophysical investigations.

2.2 Science Instrument Summary Description

The Payload consists of an afocal anastigmatic telescope with an internal scan mirror and re-imaging camera. The entire instrument is mounted inside a solid hydrogen cryostat to enable sensitive detection at mid-infrared wavelengths. The optics arrangement allows a single field of view to be imaged in four wavelength bands during each exposure. The scan mirror cancels the motion of the flight system for the detector integration time. The two shorter wavelength bands utilize HgCdTe detectors on existing Rockwell HAWAII 1RG multiplexers, while the longer two wavelength bands use Si:As detectors on a new cryogenic multiplexer.

3. PROJECT DEFINITION

3.1 Project Organization and Management

The PI is responsible for the overall success of the WISE Project and is accountable to the AA/SMD for the scientific success of the mission. Education and public outreach will be acquired by UCLA from the University of California at Berkeley. The PI has delegated day-to-day management of the WISE project to the Jet Propulsion Laboratory who will also provide mission level system engineering and mission operations leadership. JPL will acquire payload, spacecraft and science data processing from external sources described below. The relationship between GSFC and JPL is governed by MOU – 2002-520-203. The GSFC Center Director is responsible for certifying WISE flight readiness to the AA/SMD.

3.2 Acquisition Strategy

JPL will contract with Ball Aerospace and Technology Corporation (BATC) to provide the spacecraft, lead flight system test, and support launch operations; and with Utah State University's Space Dynamics Laboratory (SDL) to provide the payload. JPL will employ Caltech's Infrared Processing and Analysis Center (IPAC) through a JPL - Caltech Work Order to provide science data processing capability.

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4. PROGRAMMATIC REQUIREMENTS

4.1 Science Requirements

4.1.1 Baseline Science Requirements

WISE shall carry out a mid-infrared, all-sky imaging survey.

4.1.1.1 Baseline Instrument Requirements

- a) The WISE survey shall consist of images in four filter bandpasses with wavelength centers within 10% of 3.3, 4.7, 12, and 23 micrometers.
- b) The WISE survey shall obtain four or more independent exposures in each filter over at least 95% of the sky.
- c) The WISE survey shall achieve a signal to noise ratio (SNR) of 5 or more on point sources with fluxes of 0.12, 0.16, 0.65, and 2.6 mJy at 3.3, 4.7, 12, and 23 micrometers respectively, where the noise is limited to flux errors due to zodiacal foreground emission, instrumental effects, source photon statistics, and unresolved extragalactic sources.

4.1.1.2 Baseline Mission Data Requirements

- a) WISE shall produce a digital atlas of images which combine the multiple survey exposures.
- b) WISE shall produce a catalog of sources associated with the image atlas.
- c) The WISE catalog shall have greater than 99.9% reliability for sources detected in at least one band with $\text{SNR} > 20$, where the noise includes flux errors due to zodiacal foreground emission, instrumental effects, source photon statistics, and neighboring sources. This requirement shall not apply to sources that are superimposed on an identified artifact.
- d) The WISE catalog shall be at least 95% complete for sources with $\text{SNR} > 20$ in at least one band, where the noise includes flux errors due to zodiacal foreground emission, instrumental effects, source photon statistics, and neighboring sources. This requirement shall not apply to sources that are superimposed on an identified artifact.
- e) The root mean square error in relative photometric accuracy of the WISE catalog shall be better than 7% in each band for unsaturated point sources with $\text{SNR} > 100$, where the noise includes flux errors due to zodiacal foreground emission, instrumental effects, source photon statistics, and neighboring sources. This requirement shall not apply to sources that are superimposed on an identified artifact.
- f) The root mean square error in WISE catalog positions with respect to 2MASS catalog positions shall be less than $0.5''$, for sources with $\text{SNR} > 20$ in at least one WISE band, where the noise includes flux errors due to zodiacal foreground emission, instrumental

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effects, source photon statistics, and neighboring sources. This requirement shall not apply to sources that are superimposed on an identified artifact.

g) The WISE catalog shall include sources to SNR 5 in any band and the completeness and reliability of sources in the catalog shall be characterized at all flux levels.

h) The WISE source catalog and image atlas shall be made publicly available within 17 months of the end of on-orbit data collection, via the Infrared Science Archive, the NASA-designated archive center for infrared and submillimeter astronomy missions.

4.1.1.3 Full Mission Success Criteria

Baseline Science Requirements 4.1.1.1 a, b, and c; and 4.1.1.2 c, d, e, f, and g; must be met to satisfy the full mission success criteria.

4.1.2 Minimum Science Requirements

WISE shall carry out a mid-infrared, all-sky imaging survey.

4.1.2.1 Minimum Instrument Requirements

a) The WISE survey shall consist of images in at least three filter bandpasses with wavelength centers between 2.2 and 50 micrometers.

b) The WISE survey shall obtain two or more independent exposures over at least 90% of the sky in each filter.

c) The WISE survey shall achieve a signal to noise ratio (SNR) of 5 or more in three bands on sources for which the product of frequency and flux density is 10^{-12} ergs/cm²/sec, where the noise is limited to flux errors due to zodiacal foreground emission, instrumental effects, source photon statistics, and unresolved extragalactic sources.

4.1.2.2 Minimum Mission Data Requirements

a) WISE shall produce a digital atlas of images which combine the multiple survey exposures.

b) WISE shall produce a catalog of sources associated with the image atlas.

c) The WISE catalog shall have greater than 99.9% reliability for sources detected in at least one band with SNR > 20, where the noise includes flux errors due to zodiacal foreground emission, instrumental effects, source photon statistics, and neighboring sources. This requirement shall not apply to sources that are superimposed on an identified artifact.

d) The WISE catalog shall be at least 90% complete for sources detected in at least one band with SNR > 20, where the noise includes flux errors due to zodiacal foreground emission, instrumental effects, source photon statistics, and neighboring sources. This requirement

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shall not apply to sources that are superimposed on an identified artifact.

e) The root mean square error in relative photometric accuracy of the WISE catalog shall be better than 10% in each band for unsaturated point sources with $\text{SNR} > 100$, where the noise includes flux errors due to zodiacal foreground emission, instrumental effects, source photon statistics, and neighboring sources. This requirement shall not apply to sources that are superimposed on an identified artifact.

f) The root mean square error in WISE catalog positions with respect to 2MASS catalog positions shall be less than $1''$ for sources with $\text{SNR} > 20$ in at least one WISE band, where the noise includes flux errors due to zodiacal foreground emission, instrumental effects, source photon statistics, and neighboring sources. This requirement shall not apply to sources that are superimposed on an identified artifact.

4.1.2.3 Minimum Mission Success Criteria

Minimum Science Requirements 4.1.2.1 b and c; and 4.1.2.2 c, d, e, and f; must be met to satisfy the minimum mission success criteria.

4.2 Mission and Spacecraft Performance

WISE shall survey the sky for at least 6 months following checkout.

4.3 Launch Requirements

WISE shall be launched into a circular, 500 km, sun synchronous, 6 am/6 pm ascending node, polar orbit by a Delta 7320. Launch shall be provided by KSC. The WISE flight system shall be compatible with a launch on any day of the year. The WISE launch readiness date shall be in June 2009.

4.4 Ground System Requirements

The WISE flight system shall be compatible with data return through TDRSS.

5. NASA MISSION COST REQUIREMENTS

5.1. Cost Cap

WISE project funding is capped at \$289.5 M Real Year Dollars (RY\$) for design, development, mission operations, and data analysis and archiving. Launch and associated launch vehicle integration and accommodation costs of \$77.1 M RY\$ are included under this cap. These costs are based on a single manifest launch. Any increases in LV cost due to either cost growth beyond the WISE Project control or NASA-directed LV changes are not included in the cost cap, nor is the cost of GSFC oversight.

5.2. Cost Management and Scope Reduction

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Provided that Program Level Requirements are preserved, and that due consideration has been given to the use of budgeted contingency and planned schedule contingency, the WISE project shall pursue scope reduction and risk management as a means to control cost. The WISE Project Plan shall include potential scope reductions and the time frame in which they could be implemented. If other methods of cost containment are not practical, the reductions identified in the WISE Project Plan may be exercised; however any reduction in scientific capability below the baseline requirements, including those reductions specifically identified in the Project Plan, shall be implemented only after consultation with and approval by the Program Scientist. Any potential scope reductions affecting these Program Requirements shall be agreed to by the signers of this document.

6. MULTI-MISSION NASA FACILITIES

The WISE project shall use the following NASA facilities:

- Kennedy Space Center WTR launch facilities;
- Goddard Space Flight Center Spectrum Management for NTIA licensing using government frequencies;
- Goddard Space Flight Center Flight Dynamics Facility for early orbit tracking of the observatory;
- TDRSS facilities for commanding and data retrieval;
- Infrared Science Archive (IRSA) facilities for data archiving and dissemination.

7. EXTERNAL AGREEMENTS

There are no external agreements.

8. PUBLIC OUTREACH AND EDUCATION

The WISE project shall develop and execute an Education and Public Outreach Plan consistent with information provided as a part of the NASA Headquarters SMD Confirmation Review.

Images shall be made available for outreach purposes within one month of the end of in orbit checkout.

9. SPECIAL INDEPENDENT EVALUATION

The WISE project shall conduct independent peer reviews according to the guidelines of JPL's Flight Project Practices and support system level reviews by the GSFC/JPL appointed Integrated Independent Review Team (IIRT). Further, the WISE project shall support the NASA Independent Validation and Verification (IV&V) software activities conducted by the NASA IV&V Facilities

10. WAIVERS

The WISE project shall provide, to the Directorate Program Management Council at the Confirmation Review, a list of requested waivers to NPR 7120.5c, submitted on the waiver form specified in the referenced document. NASA policy for systems of measurement to be

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used on NASA programs/projects is detailed in NPD 8010.2 "Use of the Metric System of Measurement in NASA Programs". The WISE Project will use SI Units (metric) system of measurement with controlled use of hybrid units when full implementation of the metric system is not feasible due to U.S. manufacturing facility requirements, the high cost of converting from English to metrics, and schedule impacts due to this conversion process.

11. Approvals

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12. Concurrences

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